MFSR Chinook Spawn Timing Phenology

2025-04-23

Methods

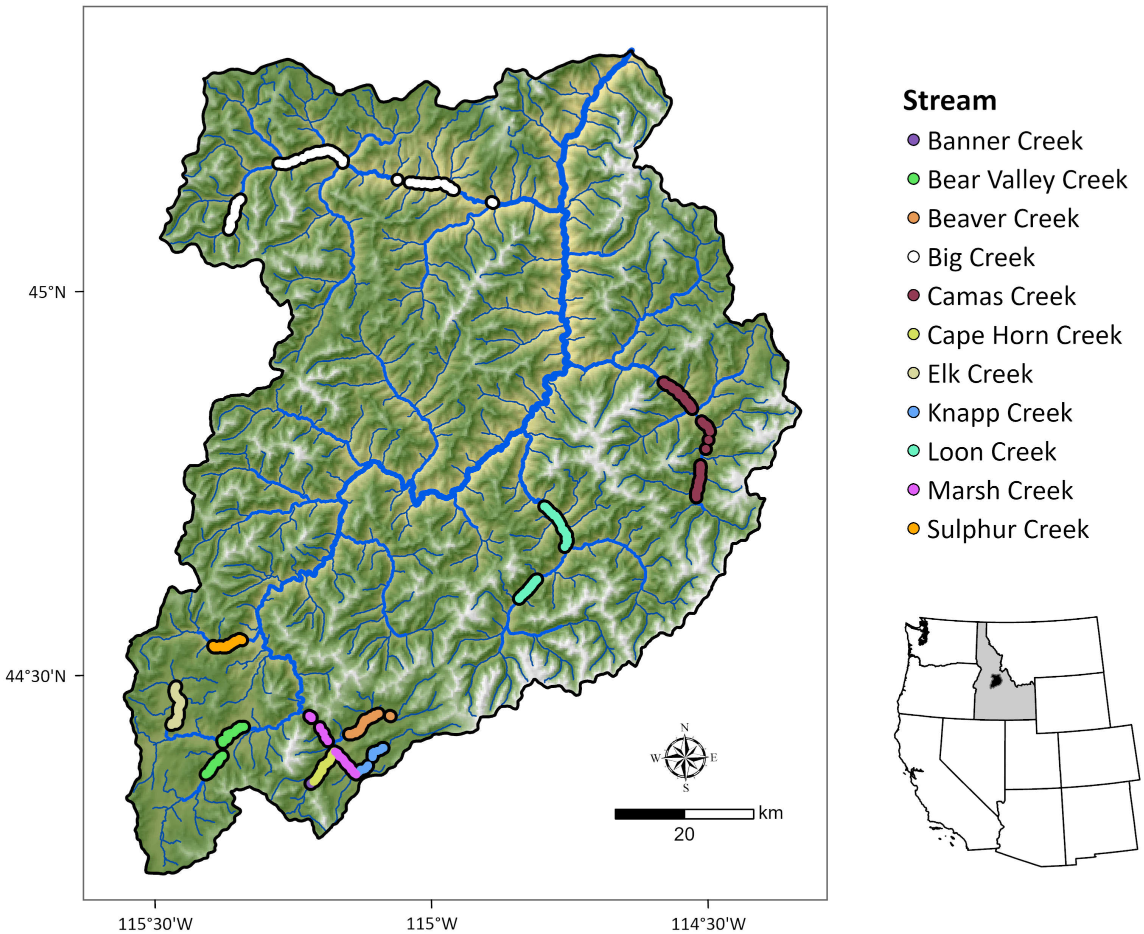
In this paper, we examine how stream geomorphic attributes, water temperature profiles, habitat features, climatic factors, and spawning escapements influence wild Chinook salmon phenotypic diversity, specifically, the timing of spawning. We compare detailed salmon spawn timing data across four years in twelve stream reaches within six major watersheds, all within a relatively intact river basin in central Idaho.

Study area

(Text below verbatim from Isaak and Thurow 2006)

This study was conducted in the Middle Fork of the Salmon River (MFSR) in central Idaho (Fig. 1). The MFSR drains 7330 km2 of forested and steeply mountainous terrain in central Idaho that ranges in elevation from 1000 to 3150 m. Most of the area (>95%) is administered by the USDA Forest Service and was managed as a primitive area from 1930 to 1980 before receiving permanent protection as part of the Frank Church – River of No Return – Wilderness in 1980. As a result, road and trail densities are low and most areas exist in relatively pristine condition. Some areas continue to recover from the effects of grazing or mining, but cessation of many of these activities has occurred since wilderness designation and listing of Snake River salmon stocks under the Endangered Species Act. Natural disturbances from fires, hillslope movements, and floods persist, and these processes maintain a dynamic mosaic of landscape conditions.

Figure 1. Map of the Middle Fork Salmon River (MFSR) study area showing redd locations (2002-2005) and stream reaches.



Spawn timing data

Spawn timing data for Chinook salmon were collected from 2002 to 2005 in the MFSR. DETAILS.

To describe variation in spawn timing, we used redd counts from XX stream reaches (Fig. 1) in the MFSR. Redd counts were conducted… Redds were counted by walking the stream and visually identifying redds. The number of redds was recorded for each stream reach and the date of the count was noted. The data were then compiled into a single dataset for analysis.

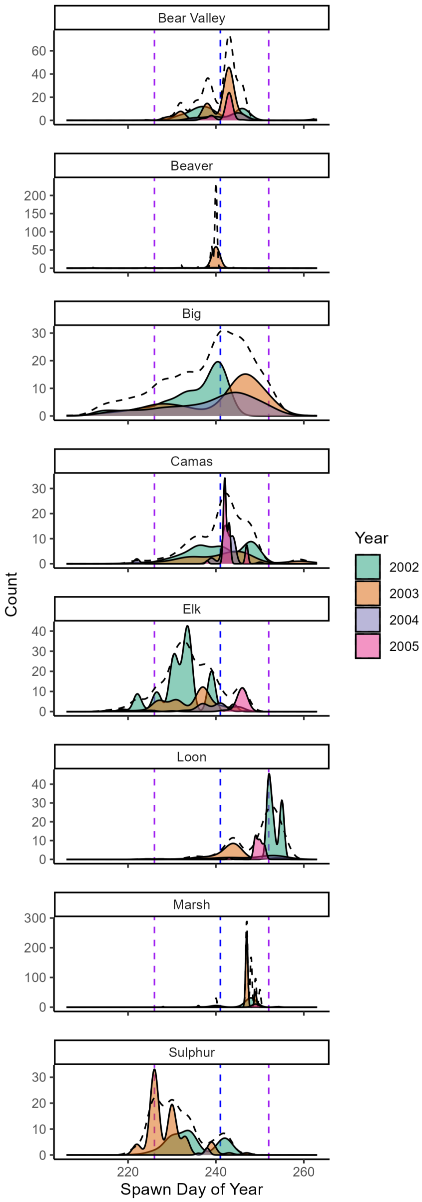


Figure 2. Temporal distribution of spawn timing for Chinook salmon in the MFSR. 2002-2005.

- colors = year
- x axis = day of year
- y-axis = count of unique redds
- dashed lines (black) = average spawning distribution by site across all years
- vertical dotted lines (purple) = 5th and 95th quantile for ALL MFSR redds across years

- vertical dotted line (blue): median (50th quantile) for ALL MFSR redds across years

Proportional cumulative redds

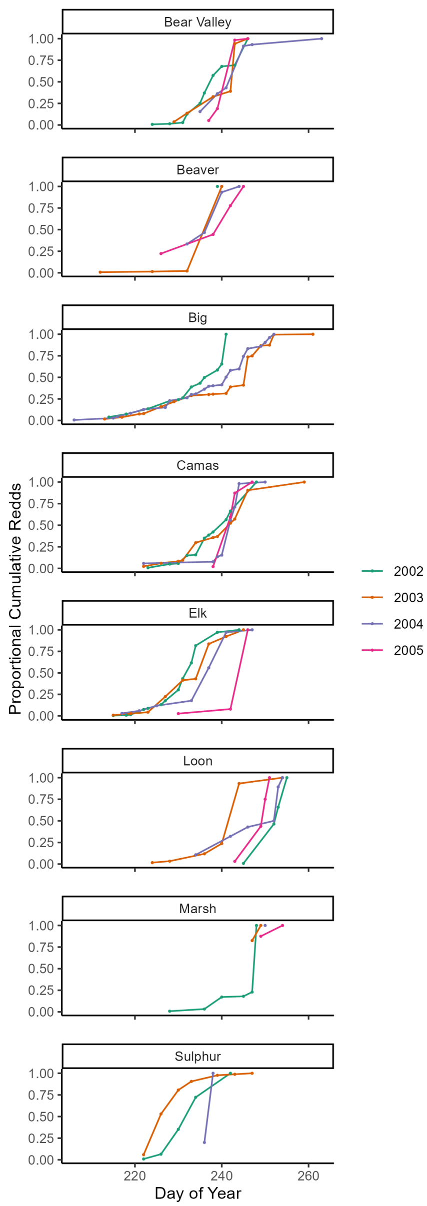


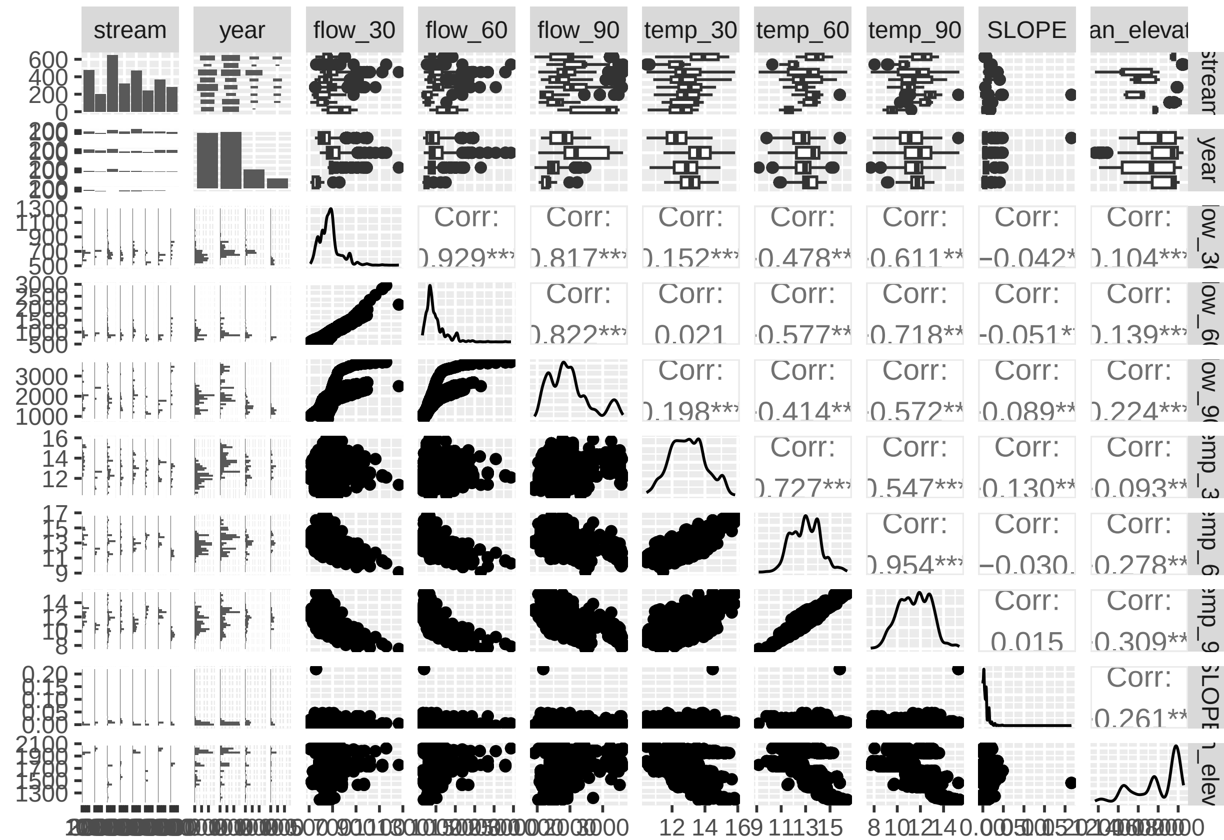
Figure 3. Proportional cumulative redds by stream.

- color = year
- x-axis = day of year
- y-axis = Proportional cumulative redds

Models and model selection

Import data and combine:

Now we check for colinearity between covariates (expect temp and flow to be bad). Remove covariates with corr >= 0.6.



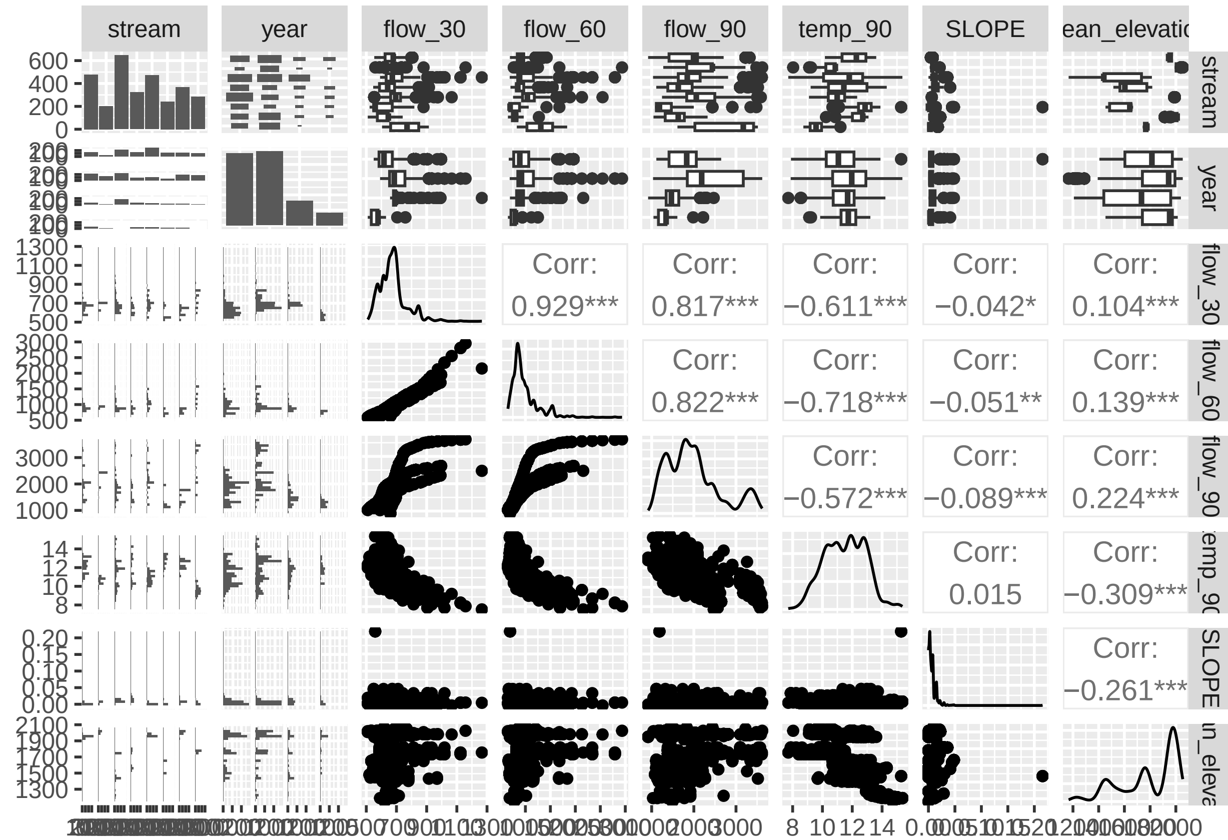
If we look at the above figure we see temperature and flow at the 30, 60, and 90 day intervals are colinear with one another within the larger covariate (temp or flow). So we need to choose our best predictive variable from that set (though note corr of temp_30 and temp_90 are <0.6, barely).

We also see high correlation between temp_90 and the different flow metrics. So we will look to see which temp metric to choose and make decisions about which flow metrics to include after.

```
##       df      AIC
## lm_30  3 21349.49
## lm_60  3 19738.48
## lm_90  3 18003.79
```

We can see the model with 90 days of temperature before spawning is much better than the other models (delta AIC = 1734.69)

Let's look at correlation again when removing temp_60 and temp_30.



So now we see that flow_30 and flow_60 are highly correlated with temp_90 so we need to also remove those. Our final model coviates then will be temp_90, slope, elevation, year, site, and abundance (once added).

```
##                 df      AIC
## full_model      16 14264.37
## int_model       23 13662.93
## intercept_model  2 21367.91
```

From AIC selection we see that the interaction model preforms the best by far. We can look at the model output below.

```
##
## Call:
## lm(formula = yday ~ year + flow_90 + temp_90 * stream + SLOPE +
##     mean_elevation, data = model_data_final)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -12.9888  -0.9675   0.2593   1.4320  13.6831
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)            234.32938    0.24895 941.271  < 2e-16 ***
## year2003                 5.38151    0.24004  22.419  < 2e-16 ***
## year2004                -0.62055    0.15453  -4.016 6.08e-05 ***
```

```
## year2005              -0.78716    0.20140  -3.908 9.49e-05 ***
## flow_90               -6.51185    0.14034 -46.401  < 2e-16 ***
## temp_90                2.17725    0.21667  10.049  < 2e-16 ***
## streamBeaver           4.40139    0.44221   9.953  < 2e-16 ***
## streamBig              6.56604    0.60065  10.931  < 2e-16 ***
## streamCamas            5.46363    0.42747  12.781  < 2e-16 ***
## streamElk              0.60421    0.20067   3.011  0.00263 **
## streamLoon             8.28262    0.51204  16.176  < 2e-16 ***
## streamMarsh            3.03676    0.27266  11.138  < 2e-16 ***
## streamSulphur          6.47217    0.63279  10.228  < 2e-16 ***
## SLOPE                 -0.02845    0.04980  -0.571  0.56780
## mean_elevation         3.78439    0.27815  13.605  < 2e-16 ***
## temp_90:streamBeaver   3.84665    0.53895   7.137 1.19e-12 ***
## temp_90:streamBig      3.40988    0.23547  14.481  < 2e-16 ***
## temp_90:streamCamas    1.12956    0.22748   4.965 7.24e-07 ***
## temp_90:streamElk      4.18607    0.29141  14.365  < 2e-16 ***
## temp_90:streamLoon     1.81809    0.37213   4.886 1.08e-06 ***
## temp_90:streamMarsh   -3.12560    0.35759  -8.741  < 2e-16 ***
## temp_90:streamSulphur  0.99663    0.41245   2.416  0.01574 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.321 on 2994 degrees of freedom
## Multiple R-squared:  0.9234, Adjusted R-squared:  0.9228
## F-statistic:  1718 on 21 and 2994 DF,  p-value: < 2.2e-16
```

Rˆ2 =0.923!